WE CLAIM

1. A linear optical signal sampler apparatus for measuring temporal samples of a modulated optical signal (MOS), the linear optical signal sampler apparatus comprising

a pulsed optical signal (POS) having energy in the same polarization as the MOS and operable at a pulse rate equal to a fraction of the modulation rate of the MOS;

a hybrid having a first input for receiving the MOS and a second input for receiving the POS, the hybrid combining the MOS and POS to produce temporal quadrature samples S_A and S_B of the interference of the electrical fields of the MOS with the POS, the optical signals corresponding to the S_A quadrature samples being outputted at a first and second outputs, and the optical signals corresponding to the S_B quadrature samples being outputted at a third and fourth outputs;

a balanced photodetector apparatus (BDA,BDB) coupled to the first, second, third, and fourth outputs for detecting and generating analog electrical signal representations of the S_A and S_B quadrature samples;

a sampling analog to digital (A/D) converter apparatus for sampling and generating digital representations of S_A and S_B quadratures samples, the sampling A/D converter apparatus being synchronized to the pulses of the SOS; and

a processor for compensating for optical and electrical signal handling imperfections in the hybrid, balanced detectors, and A/D converters and for measuring temporal signal samples by generating a demodulated sampled data pulse from the quadratures samples S_A and S_B.

2. The optical signal sampler apparatus of claim 1 wherein the processor compensates for signal handling imperfections in the generation and detection of the two quadratures by numerically scaling quadratures samples S_A and S_B over a large collection of samples by imposing that the average $\langle S_A \rangle = \langle S_B \rangle = 0$ and $\langle S_A^2 \rangle = \langle S_B^2 \rangle$ and generating a demodulated sampled data pulse having a power equal to the sum $S_A^2 + S_B^2$.

3. The optical signal sampler apparatus of claim 1 wherein the processor controls the relative phase between quadratures samples S_A and S_B by ensuring that $2\langle S_A \cdot S_B \rangle / (\langle S_A^2 \rangle + \langle S_B^2 \rangle)$ is equal to zero by adjusting the phase between the quadrature samples S_A and S_B in the hybrid or by numerical processing of quadrature samples S_A and S_B.

4. The optical signal sampler apparatus of claim 1 wherein the hybrid includes

a phase adjuster operable in response to a control signal from the processor for adjusting the relative phase between the S_A and a S_B quadratures.

5. The optical signal sampler apparatus of claim 1 wherein the hybrid includes

a first interference coupler for receiving the MOS and POS signals and for producing the S_A quadratures samples and

a second interference coupler for receiving the MOS and POS signals and for producing the S_B quadratures samples.

6. The optical signal sampler apparatus of claim 1 being implemented using an arrangement of waveguides to minimize any differences in the S_A and S_B quadratures samples caused by any environmental factor.

7. The optical signal sampler apparatus of claim 1 wherein the hybrid includes

a first 1x2 coupler for receiving the MOS and for producing first and second MOS components;

a second 1x2 coupler for receiving pulses of POS and for producing first and second POS components;

a phase shifter for introducing a predetermined phase shift delay in the second POS component;

a first 2x2 interference coupler for receiving the first MOS component and the first POS component and for producing the S_A quadrature samples;

a second 2x2 interference coupler for receiving the delayed second MOS component and the second POS component and for producing the S_B quadrature samples.

8. The optical signal sampler apparatus of claim 1 wherein the processor apparatus includes means to

(A) numerically scale the two quadratures interference samples S_A and S_B over a large collection of samples by imposing that $<S_A> = <S_B> = 0$ and $<S_A^2> = <S_B^2>$, where the brackets represent the average value calculated over a large number of samples;

(B) calculate $<S_A>$, then calculate $S_A'=S_A-<S_A>$ and use it for all subsequent operations;

(C) calculate $<S_B>$, then calculate $S_B'=S_B-<S_B>$ and use it for all subsequent operations;

(D) calculate $\sigma_A'2=<S_A'^2>$, then calculate $\sigma_B'2=<S_B'^2>$, then define S_A'' and S_B'' such as $S_A''=S_A''/\sigma_A'$ and $S_B''=S_B''/\sigma_B'$;

(E) calculate the quantity $2 < S_A'' \cdot S_B'' > / (< S_A''^2 > + < S_B''^2 >)$, which is equal to the cosine of the relative phase between the two quadratures, which since the relative phase is equal to either $\pi/2$ or $-\pi/2$ should equal zero;

(E) adjust the relative phase between the two quadratures so that the calculated $2 < S_A'' \cdot S_B'' > / (< S_A''^2 > + < S_B''^2 >)$ is close to zero; and

(F) generate, for each sample, a demodulated sampled data pulse signal having a power equal to the sum $S_A''^2 + S_B''^2$.

9. The optical signal sampler apparatus of claim 1 being implemented using an arrangement of waveguides to minimize any differences in the S_A and S_B quadratures samples caused by environmental factors.

10. A linear optical signal sampler apparatus for measuring temporal samples of a modulated optical signal source (MOS) , the linear optical signal sampler apparatus comprising

a pulsed optical signal source (POS) having energy in the same polarization as the MOS and operable at a pulse rate equal to a fraction of the data modulation rate of the DOS;

a 90^0 hybrid implemented using an arrangement of waveguides and including a first input for receiving the MOS and a second input for receiving the POS, the hybrid further including

a first interference coupler for generating interference of the electrical fields of the MOS with the POS to produce S_A quadrature samples, the optical signals producing the S_A quadrature samples being outputted at first and second outputs of the hybrid, and

a second interference coupler for generating interference of the electrical fields of theMOS with the POS to produce S_B quadrature samples, the MOS phase being adjusted so that the relative phase between the S_B quadrature samples and the S_A quadrature samples **is $\pi/2$,** the optical signals producing the S_B quadrature samples being outputted at third and fourth outputs of the hybrid;

a first balanced photodetector (BDA), operable at the pulse rate of the POS, coupled to the first and second outputs for detecting and generating analog electrical signal representations of the S_A quadrature samples;

a second balanced photodetector (BDB), operable at the pulse rate of the POS, coupled to the third and fourth outputs for detecting and generating analog electrical signal representations of the S_B quadrature samples;

a sampling analog/digital (A/D) converter apparatus for sampling and generating digital representations of the S_A and S_B quadratures samples, the sampling A/D converter apparatus being synchronized to the pulses of the SOS; and

a processor apparatus for measuring temporal signal samples using two quadratures samples S_A and S_B and for generating therefrom the demodulated pulse.

11. The optical signal sampler apparatus of claim 10 wherein the hybrid includes

a polarizer for splitting the MOS (E_D) into an x and y polarizations;

a polarizer for splitting the POS (E_P) into an x and y polarizations;

a first hybrid for sampling the x polarization of the MOS and POS to form the S_A and S_B quadrature samples of the x polarization;

a second hybrid for sampling the y polarization of the MOS and POS to form the S_A and S_B quadrature samples of the y polarization; and wherein the balanced photodetector apparatus includes

a first pair of balanced photodetectors (BDA,BDB) for detecting and generating analog electrical signal representations of the S_A and S_B quadrature samples of the x polarization; and

a second pair of balanced photodetectors (BDC,BDD) for detecting and generating analog electrical signal representations of the S_A and S_B quadrature samples of the y polarization.

12. The optical signal sampler apparatus of claim 10 wherein the hybrid includes

a polarizer for splitting the MOS (E_D) into an x and y polarizations;

a splitter for splitting an x polarized POS (E_P) into a first and second sampling POS pulses;

a half-wave plate for rotating the second sampling POS pulse into a y polarization POS pulse;

a first hybrid or sampling the x-polarized MOS and the x-polarized first sampling pulse to form the S_A and S_B quadrature samples of the x polarization;

a second hybrid for sampling the y-polarized MOS and the y-polarized POS pulse to form the S_A and S_B quadrature samples of the y polarization; and wherein the balanced photodetector apparatus includes

a first pair of balanced photodetectors (BDA,BDB) for detecting and generating analog electrical signal representations of the S_A and S_B quadrature samples of the x polarization; and

a second pair of balanced photodetectors (BDC,BDD) for detecting and generating analog electrical signal representations of the the S_A and S_B quadrature samples of the y polarization.

13. The optical signal sampler apparatus of claim 10 wherein the hybrid includes

a first hybrid unit including

a 1x2 coupler for receiving the MOS polarized with energy in both polarizations and for producing first and second MOS components;

a second 1x2 coupler for receiving pulses of POS and for producing first and second POS components;

a first 2x2 interference coupler for receiving the first MOS component and the first POS component and for producing the S_A quadrature samples;

a second 2x2 interference coupler for receiving the delayed second MOS component and the second POS component and for producing the S_B quadrature samples;

four polarizers for splitting the recombined fields from the first and second interference couplers into linear polarizations x and y;

a first pair of balanced photodetectors (BDA,BDC) arranged for detecting and generating analog electrical signal representations of the S_A and S_C quadrature samples of the MOS of the x polarization;

a second pair of balanced photodetectors (BDB,BDD) arranged for detecting and generating analog electrical signal representations of the S_B and S_D quadrature samples of the MOS of the y polarization; and wherein

the processor operates independently on the S_A and S_C quadrature samples and the S_B and S_D quadrature samples.

14. An optical receiver for demodulating the data from a modulated optical signal source (MOS) received over an optical facility, the optical receiver comprising

a pulsed optical signal source (POS), having energy in the same polarization as the MOS, operable at a pulse rate equal to the modulation rate of the MOS;

a 90^0 hybrid having a first input for receiving the MOS and a second input for receiving the POS, the hybrid combining the MOS and POS to produce a S_A and a S_B quadratures samples of the interference of the electrical fields of the MOS with the POS, the signals corresponding to the S_A quadrature samples being outputted at a first and second

outputs, respectively, and the signals corresponding to the S_B quadrature samples being outputted at a third and fourth outputs, respectively;

a first balanced photodetector (BDA), operable at the data modulation rate of the MOS, coupled to the first and second outputs for detecting and generating analog electrical signal representations of the S_A quadrature samples;

a second balanced detector BDB, operable at the data modulation rate of the MOS, coupled to the third and fourth outputs for detecting and generating analog electrical signal representations of the S_B quadrature samples;

a sampling analog/digital (A/D) converter apparatus for sampling and generating digital representations of the S_A and S_B quadratures samples, the sampling A/D converter apparatus being synchronized to the pulses of the SOS; and

a processor apparatus for processing the two quadratures samples S_A and S_B and for generating therefrom a demodulated sample data output.

15. A method of operating an optical signal sampler apparatus for measuring temporal samples of a modulated optical signal (MOS), comprising the steps of:

(1) receiving a data modulated optical signal (MOS);

(2) receiving a pulsed optical signal (POS) at a pulse rate equal to a fraction of the modulation rate of the MOS;

(3) producing a S_A and a S_B quadratures samples of the interference of the electrical fields of the MOS with the POS;

(4) detecting and generating digital representations of the real and imaginary components of the S_A and S_B quadratures samples;

(5) compensating for optical and electrical signal handling imperfections in the apparatus used to perform steps (3) and (4);

(6) measuring temporal signal samples by generating a demodulated sampled pulse from the quadratures samples S_A and S_B .

16. A method of claim 15 wherein the measuring step includes the steps of:

(A) numerically scaling the two quadratures interference samples S_A and S_B over a large collection of samples by imposing that the average $\langle S_A \rangle = \langle S_B \rangle = 0$ and average $\langle S_A^2 \rangle = \langle S_B^2 \rangle$, where the brackets represent the average value calculated over a large number of samples;

(B) calculating $\langle S_A \rangle$, then calculating $S_A' = S_A - \langle S_A \rangle$ and using it for all subsequent operations;

(C) calculating $\langle S_B \rangle$, then calculating $S_B' = S_B - \langle S_B \rangle$ and using it for all subsequent operations;

(D) calculating $\sigma_A'2 = \langle S_A'^2 \rangle$, then calculating $\sigma_B'2 = \langle S_B'^2 \rangle$, then define S_A'' and S_B'' such as $S_A'' = S_A''/\sigma_A'$ and $S_B'' = S_B''/\sigma_B'$;

(E) calculating the quantity $2 \langle S_A'' \cdot S_B'' \rangle / (\langle S_A''^2 \rangle + \langle S_B''^2 \rangle)$, which is equal to the cosine of the relative phase between the two quadratures, which since the relative phase is equal to either $\pi/2$ or $-\pi/2$ should equal zero;

(F) adjusting the relative phase between the two quadratures so that the calculated $2 \langle S_A'' \cdot S_B'' \rangle / (\langle S_A''^2 \rangle + \langle S_B''^2 \rangle)$ is close to zero; and

(G) generating, for each sample, a demodulated sample data pulse signal equal to the sum $S_A''^2 + S_B''^2$.